# PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.: —H 04 q 9/12

## COMPLETE SPECIFICATION

## Electrical Control System

We, THE HORSTMANN GEAR COMPANY, LIMITED, a British Company, of Newbridge Works, Bath, Somerset, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

THIS INVENTION relates to electrical control systems, and more particularly to control systems for controlling the switching on or off, or other phases of operation, of equipment installed at a distance from a control point, by means of high frequency signals, which may be V.H.F. or S.H.F. signals, transmitted by wire.

Numerous systems have been devised by which a central transmitter is enable selectively to call one or more receiving stations and either communicate information or cause a particular activity to occur. In many of these systems each receiving station contains one or more tuned circuits and the called station responds to a particular frequency, or a series of frequencies which are transmitted in sequence, either in ascending or descending order of frequncy, or in a predetermined order of frequencies.

In order to increase the efficiency of electric supply systems it is now common practice for electric supply authorities to offer a cheap rate to consumers who are prepared to instal special equipment, such as storage heaters, which can be supplied solely during "off-peak" periods, that is to say, periods of the day or night in which the normal demand for electricity is light. The usual method of controlling the off-peak loads at the present time is to have a second supply meter which supplies the off-peak apparatus and which is used in conjunction with a time switch to switch on this apparatus during the off-peak periods. These time switches are set to provide the supply at set periods but it would be a great advantage if some form of central control could be provided by which off-peak loads can be switched on during any periods in which the normal load happens to be sufficiently light to enable the "off-peak" load to be carried.

In a similar manner, street lighting is at present mainly controlled by time switches, usually a separate switch installed at each lamp standard, and these are set to switch the street lamps on and off at specific times. However, these time switches may have to be periodically re-set in the course of the year because of the seasonal changes in lighting-up times. Furthermore, the street lamps are not illuminated at other times when they would be useful as, for example, during misty or foggy weather or in case of heavy storms during which the streets may become dark at unaccustomed times. The same considerations apply to illuminated traffic bollards and road signs and there are other types of equipment whose functions it would be desirable to control automatically and which it would also be desirable to be able to control *en masse* from a central control point, e.g. factory machine control, chemical plant control, and medical intensive care unit monitoring.

The invention may also ve used in conjunction with the invention disclosed in our co-pending patent application No. 43,861/68 (Serial No. 1140252) in which the receiver is caused to report a local condition, for ex-

[*Price* 4*s.* 6*d.*]

ample, the reading of an electricity meter or the load on a local distribution transformer.

One object of the invention is to provide means for operating such controls or apparatus by the use of a pilot cable, which may for example be a cable which is also used for the distribution of wired television and radio programmes or a telephone line. However, the invention also contemplates that special pilot cables might be installed for these control purposes.

A system of this kind, in order to be secure and reliable, must be proof against operation by spurious signals which either occur accidentally or are deliberately generated with the object of tampering with the system. The system according to the invention over-comes this difficulty by providing two frequencies or groups of frequencies, one being a frequency or group of frequencies, referred to as a "guard" or command frequency or frequencies, which opens a gate or gates in the receiver, and the second frequency or group of frequencies being an actuating frequency or frequencies to which the receiver is responsive. The actuating frequency may be a low frequency and it may be provided by modulating the guard frequency. Alternatively, it may be a sweep of frequencies over a predetermined range.

The invention consists of an electrical control system comprising a master transmitter equipped to generate and transmit to a plurality of receivers over a single pilot cable extending to all the receivers one or more command frequencies, the command frequencies being transmitted simultaneously if there are more than one, the master transmitter being further equipped to generate and transmit one or more actuating frequencies over the said single pilot cable while maintaining the command frequency or frequencies, each receiver being equipped with one or more frequency responsive gates which are opened by the command frequencies, each of the frequency responsive gates (if there are more than one) in any one receiver being responsive to a different command frequency, each receiver being also equipped with one or more frequency responsive circuits each of which is responsive to an actuating frequency, the frequency responsive circuit or circuits being so interconnected with the frequency responsive gate or gates in each receiver that the actuating frequency or frequencies can only be applied to the frequency responsive circuit or circuits if the frequency responsive gate, or all the frequency responsive gates if there are more than one, is/are open, and means in each receiver to carry out a desired function when one or more of the frequency responsive circuits is/are actuated.

The actuating frequency or frequencies may be provided by modulating the command frequency, or by modulating one or more of the command frequencies if there is a plurality of command frequencies.

The actuating frequencies may be provided by a sweep of frequencies extending between predetermined limits.

In one preferred form of the invention when used in conjunction with the invention disclosed in our said copending patent application, as applied to the automatic checking of electricity supply meters, a plurality of command or guard frequencies is transmitted simultaneously to open a series of frequency-responsive gates, each meter having a unique combination of gates which respond to different combinations of guard frequencies, and the activating frequencies consist of a sweep which covers a predetermined frequency band. The electricity meter is preferably so arranged that its recording mechanism opens and closes a series of switches which provide a record of the meter reading in binary form. Each switch is associated with a tuned circuit which responds to a particular frequency in the band which is swept, so that when that particular frequency is generated the associated switch allows a signal of that frequency to pass, provided that the switch is closed. The frequencies which pass the switches are amplified and passed back to the pilot cable and a receiver at the transmitter end of the pilot cable picks up the spot frequencies within the swept band and from these reconstitutes the binary signal corresponding to the meter reading. The received binary information may be directed to a computer which compares the new meter reading with the previous reading, carries out the necessary calculations and also prepares an account to be sent to the consumer who occupies the particular dwelling house. This mode of the invention in conjunction with the invention disclosed in our said co-pending patent application may also be used, for example, to enable the master transmitter to command information as to the loading of an electricity sub-station or feeder cable, and the information may be used to decide the manner in which the distribution network is to be switched in relation to different sub-stations and feeder cables in order to keep the whole supply system balanced and free from local overloads.

The use of wired television and radio has been increasing considerably in recent years and the proposal to introduce a "pay television" system in which consumers would insert coins in a slot attached to their television receivers in order to receive special programmes transmitted by a private company, is likely to increase the use of wired television systems. The systems involve the installation of cables in individual dwelling houses over which several television programmes and radio programmes may be transmitted. The feeder cables are usually laid underground, as are the normal electric supply mains. The usual

manner in which the wired radio and television systems operate is to provide an aerial site, usually on high ground near the town or city which is to be served, the site providing good radio and television signals, and the signals which are picked up are amplified and fed into a main trunk network of co-axial cables laid in the town or city. At intervals in this system amplifiers boost the signals to their original level. All this is entirely automatic and requires no continuous manual control. Feeders are taken from the main trunk system and from these feeders the consumer service cables are led into the individual dwelling houses (or flats) in which co-axial terminations are fitted, with leads connected to the input sockets of the consumer's radio and/or television apparatus. These distribution systems provide a stable signal of good quality, both for television and sound radio.

The equipment and cables used in the majority of relay systems is quite able to handle a considerably greater range of signals than television or radio would ever demand and this leaves room for special control signals, not connected with wired radio or television, to be added without any alteration to the existing equipment, that is to say, the wired television and radio distribution system may be used as the pilot cable required for the purposes of the invention. Hence, it is possible to transmit command and actuating signals of the invention over the existing network by the use of suitable transmission and receiving equipment, which may be used to control off-peak electricity loads and other functions such as street lighting, traffic bollards, road signs and even to switch road signs where, for example, traffic is allowed to proceed along a route in one direction during the morning rush hour and is allowed to proceed along the same route in the opposite direction during the evening rush hour, in addition to providing automatic meter reading.

The equipment required for remote load control may be very simple. For example, in addition to a frequency responsive gate, a receiver could contain an inductance in series with a semi-variable tuning capacitor to provide a tuned circuit responsive to a desired frequency, which is selected by appropriate setting of the tuning capacitor, the junction of the inductance and capacitor being connected to the base of a transistor, while the other side of the capacitor is connected to the emitter thereof, the transistor being of p-n-p type. The collector of the transistor is connected to one end of the operating coil of a relay and the other end of the relay coil is connected to the negative terminal of a low voltage direct current power supply, the positive terminal of the supply being connected to the emitter of the transistor, there being a diode connected across the relay coil to pass current in the direction opposite to the normal flow of current from the power supply in order to protect the circuit against surges. This is only one possible form of receiver, and alternative circuits will occur to those versed in the art. The tuned circuit might, for example, be tuned to a frequency of the order of 200 Kc/s, and whenever this frequency appears across the input terminals, resonance will occur in the tuned circuit and the transistor will become conductive so that the relay coil is energized by the emitter/collector current of the transistor. The relay contains contacts which may operate desired control apparatus or could supply the coil of a contactor unit to control a heavy load, such as an off-peak heating load. A suitable power supply could consist of a transformer connected to the supply mains and giving at its secondary winding an output of about eight volts, with a rectifier in series with one secondary lead and a high value capacitor connected across the output terminals to provide smoothing, with a zener diode connected across the capacitor to provide a degree of stabilization.

Various features of the invention are shown in the accompanying drawings in which:—

Figure 1 shows a street plan with a system according to the invention included;

Figure 2 shows how individual dwelling houses may be connected to the system for operating off-peak heating loads and also the manner in which street lights may be operated;

Figure 3 shows a binary system by which an electricity meter reading may be reported to the master transmitting point when using the invention in conjunction with the invention disclosed in our said co-pending patent application;

Figure 4 is a diagram of a control arrangement according to the invention as applied to a whole district; and

Figure 5 is a diagram to illustrate the transmission and reception of the reporting sweep frequency to and from the supply meter shown in Figure 3.

Figure 1 shows a typical street plan for wired television/radio and comprises a main arterial feeder from the master transmitter 12 which runs through a town centre with branch lines 13 taken from it via line dividers 14. The square blocks 15 represent dwelling houses connected to the system.

Assuming that a main road runs diagonally from the site 12 in the direction of the arrow 16, it will be seen that the main feeder cable runs along the road and branches off to secondary roads and estates on either side. Line amplifiers 18 are installed at intervals along the main and secondary feeders and the numerous receivers are connected by lines from line taps 20. Street lights are indicated by asterisks 17 and those installed along the main road are conveniently controlled by radio transmitters 19 as it would, in this case, be

difficult to bring pilot wires to them, but in the side roads one set of street lights is shown fed by pilot wires as these are assumed to be adjacent the street light columns. The plan also shows how the master transmitter site will be used as the central "nerve" system for the City Engineer (to control the street lights), the Electricity Board (load control) and any other interested parties, who will be connected by telephone line to control the multi-channel master oscillator situated in the master transmitter building.

Referring to Figure 2, it is assumed that the command and actuating frequencies are transmitted in the direction of the arrow heads 21 on the main feeder line.

House A was not originally wired for radio and television so it was necessary for the Company concerned to instal a junction box 24 and take a service cable to the electricity meter position to enable a consumer receiver unit 22 to be fitted to control an off-peak heating load.

In house B an existing radio and television supply point 23a was available so it was a simple matter to attach a consumer receiver unit 23 to control the off-peak heating load.

It is assumed that house C is a different case, possibly business premises, and here the consumer receiver unit 25 responds to a different command or actuating frequency and controls dual metering. This house also had existing wiring for television or radio signals at 25a. In the units 22, 23 and 25 only the frequency responsive circuit and the relay are shown. The frequency responsive gates are omitted but it is to be understood that they are normally present.

Street light 26 is connected to the pilot cable through a junction box and a short length 27 of new cable which it was convenient to instal because of the close proximity of the street light to the pilot cable 21, the street light being provided with a receiver unit tuned to the street light control frequency.

Street light 28 cannot conveniently be wired directly to the pilot cable as it is on the far side of a busy arterial road. To meet this situation an auxiliary transmitter 29 is installed on street light 26 and a receiver 30 is installed on street light 28 which is fed from a lighting cable 31. As an alternative an ultrasonic transmitter and receiver might be used for short distances. Should the radio or ultrasonic beam be interrupted, by the passage of an exceptionally high vehicle, for example, light 28 would be extinguished. This may be prevented by arranging that the light is not extinguished until, say two minutes after the beam has ceased.

A further auxiliary transmitter 32 is installed at the end of the pilot cable for other services.

Figure 3 shows diagrammatically a basic system in which the invention is used in conjunction with the Automatic Electric Reporting System disclosed in our said co-pending patent application. This Figure shows a receiver, an electricity supply meter arranged to provide a binary coded reading, and means to transmit or report data on the meter reading back to the master transmitter. This apparatus includes separate means to control a load, such as an off-peak heating load, in addition to providing automatic meter reading. The meter may be of any ordinary kind and its mechanism 33, in addition to operating a normal decimal counting train, also operates a spindle and gear train, generally indicated by a dotted line 34. The spindle 34 and its gearing have associated with them a series of cams (not shown) which operate switches 35 to 45, to provide a binary coded reading of the meter. Each switch is associated with a tuning coil, respectively L2 to L12, and a semi-variable capacitor, respectively C2 to C12. There is a further device 46 which may comprise a switch activated by mechanism which is associated with a tuning coil L1 and a semi-variable capacitor C1. The frequencies are transmitted along the line 47 and are applied to a tuned circuit consising of an inductance $L_0$ and a capacitor $C_0$. Provided that the tuned circuit $L_0$, $C_0$ is tuned to this frequency, which is a command or guard frequency, a signal is applied to a radio frequency amplifier 48 and the output of the amplifier 48 is applied to a further tuned circuit comprising an inductance $L_A$ and a capacitor $C_A$. The frequency to which the tuned circuit $L_A$, $C_A$ responds is an actuating frequency and consists of a small band of frequencies which is covered in a sweep. This band is applied to a further amplifier 49 and is then passed to one end of each of the inductances L1 to L12.

As the frequency band is swept L1 responds first and as its resonant frequency is reached a voltage is developed across L1 and C1 and the resulting signal is passed through the device 46 and along a line 50 back to the supply line 47. This indicates to the receiving apparatus that the meter is functioning correctly and that signals corresponding to the meter reading will follow. As the frequency band is swept the resonant frequency of the bands L2, C2 to L12, C12 are successively reached and as each resonant frequency is reached the signal voltage developed across the inductance and the associated capacitor causes a signal to be transmitted through the respective switches 35 to 45, provided that these are closed. For example, when the resonant frequency of L2, C2 is reached a signal is transmitted through the switch 35, provided that this switch is closed, and it can be arranged that a signal applied to the line 50 at this point in the frequency band through the closed switch 35 indicates a "1" in the binary code and

the absence of a signal, if the switch 35 is open, indicates a "0". In this way a series of successive signals or spaces is provided when the appropriate frequency points are swept which gives a full reading of the meter. Suitable apparatus is provided in the receiver to record where, at each particular frequency, a "1" or "0" is received. The binary coded number may then be passed to a computer which will compare the reading with the previous meter reading to determine the consumption since the last reading and prepare the account for the consumer.

Figure 3 also shows a further tuned circuit $L_{II}$, $C_{II}$ generally indicated by reference 51 associated with a radio frequency amplifier 52 to respond to a further command or guard frequency, the output of the amplifier 52 being passed to a further tuned circuit $L_{I}$, $C_{I}$ generally indicated by reference 53 which responds to a further actuating frequency and is associated with a further amplifier 54 the output of which is applied to operate a switch 55 which connects peak-load or special tariff appliances such as storage heaters. As diagrammatically indicated in Figure 3, it would be necessary to apply a guard frequency and an actuating frequency for the tuned circuits 51 and 53 continuously in order to hold the switch 55 closed, but it is, of course, perfectly easy to arrange that a momentary application of these frequencies causes a relay to be actuated which has a holding circuit so that it remains operated until the guard frequency and actuating frequency are applied again to release the relay or until the guard frequency and a special "release" actuating frequency are applied. This would require still another tuned circuit for the additional actuating frequency.

Figure 5 is a block schematic diagram showing how the transmitter and receiver operate in connection with the supply meter of Figure 3. The transmitter, generally indicated by reference 56, is arranged to transmit the guard frequency or frequencies as well as the actuating frequency or frequencies (which are impressed on the guard frequency by modulation) and these are transmitted along a line 57, which is equivalent to the line 47 of Figure 3, there being a second conductor 58 which will represent the sheath in the case of a co-axial cable. The modulation frequency which is transmitted back along the line 50 in Figure 3 is accepted by the receiver 59, also connected to the conductors 57 and 58, and is dealt with as previously described.

It is quite easy so to arrange the coupling between the transmitter 56 the receiver 59 and the conductor 57 and 58 to ensure that the guard frequency and actuating frequency transmitted along conductors 57 and 58 do not affect the receiver 59, and the modulation frequency received from the conductors 57 and 58 are accepted by the receiver 59 and do affect the transmitter 56.

While Figure 3 shows the basic arrangement for obtaining a reading from a binary electricity supply meter, it will be appreciated that to provide a practical system of automatic meter reading it is necessary to be able to select any particular meter out of a very large number to obtain its reading. For this purpose it is contemplated for example that three or four different frequencies will be applied to the lines and each meter will have a unique combination of three or four frequency-selective gates. If each of the three or four guard frequencies is one of one hundred different frequencies then it will be found by calculation that the total number of different meters, each of which has a unique combination of three gates, will be 161,700 and the total number of meters each of which may have a combination of four gates is 3,921,225.

In cases where the pilot line is a line which is also used for the transmission of radio or television signals, and the line contains amplifiers at intervals along its length, it will be obvious that binary signals from a meter which has been "read" cannot pass back to the receiver which is located at the site of the transmitter, since the signals obviously cannot pass backwards through the amplifiers. The demodulated signal can, however, be passed forward through the further amplifiers to the end of the pilot line, and it is a comparatively simple matter to instal an extra line running back from the end of the pilot line to the transmitter to carry the signals from all the meters.

Figure 4 shows a plan of a district showing how the different frequencies may be transmitted to different local points and then distributed over the respective local areas. Here f1 to f9 are the different activating frequencies, each with at least one guard frequency. The items which are controlled are indicated by the key given in the drawing.

WHAT WE CLAIM IS:—

1. An electrical control system comprising a master transmitter equipped to generate and transmit to a plurality of receivers over a single pilot cable extending to all the receivers one or more command frequencies, the command frequencies being transmitted simultaneously if there are more than one, the master transmitter being further equipped to generate and transmit one or more actuating frequencies over the said single pilot cable while maintaining the command frequency or frequencies, each receiver being equipped with one or more frequency responsive gates which are opened by the command frequencies, each of the frequency responsive gates (if there are more than one)

in any one receiver being responsive to a different command frequency, each receiver being also equipped with one or more frequency responsive circuits each of which is responsive to an actuating frequency, the frequency responsive circuit or circuits being so interconnected with the frequency responsive gate or gates in each receiver that the actuating frequency or frequencies can only be applied to the frequency responsive circuit or circuits if the frequency responsive gate, or all the frequency responsive gates if there are more than one, is/are open, and means in each receiver to carry out a desired function when the or one or more of the frequency responsive circuits is/are actuated.

2. A system as claimed in claim 1 in which the actuating frequency or frequencies is/are provided by modulating the command frequency, or by modulating one or more of the command frequencies if there is a plurality of command frequencies.

3. A system as claimed in claim 1 or 2 in which the actuating frequencies are provided by a sweep of frequencies extending between predetermined frequency limits, each receiver containing frequency responsive circuits responsive to selected frequencies between the said limits.

4. A system as claimed in any preceding claim in which the means to carry out the desired function comprises a relay which is operated when the actuating frequency is applied.

5. A system as claimed in claim 4 in which the relay controls an off-peak heating load.

6. A system as claimed in claim 4 in which the relay controls a street lamp, road sign or bollard.

7. An electrical control system as claimed in claim 1 arranged and adapted to operate substantially as herein described, with reference to and as illustrated in the accompanying drawings.

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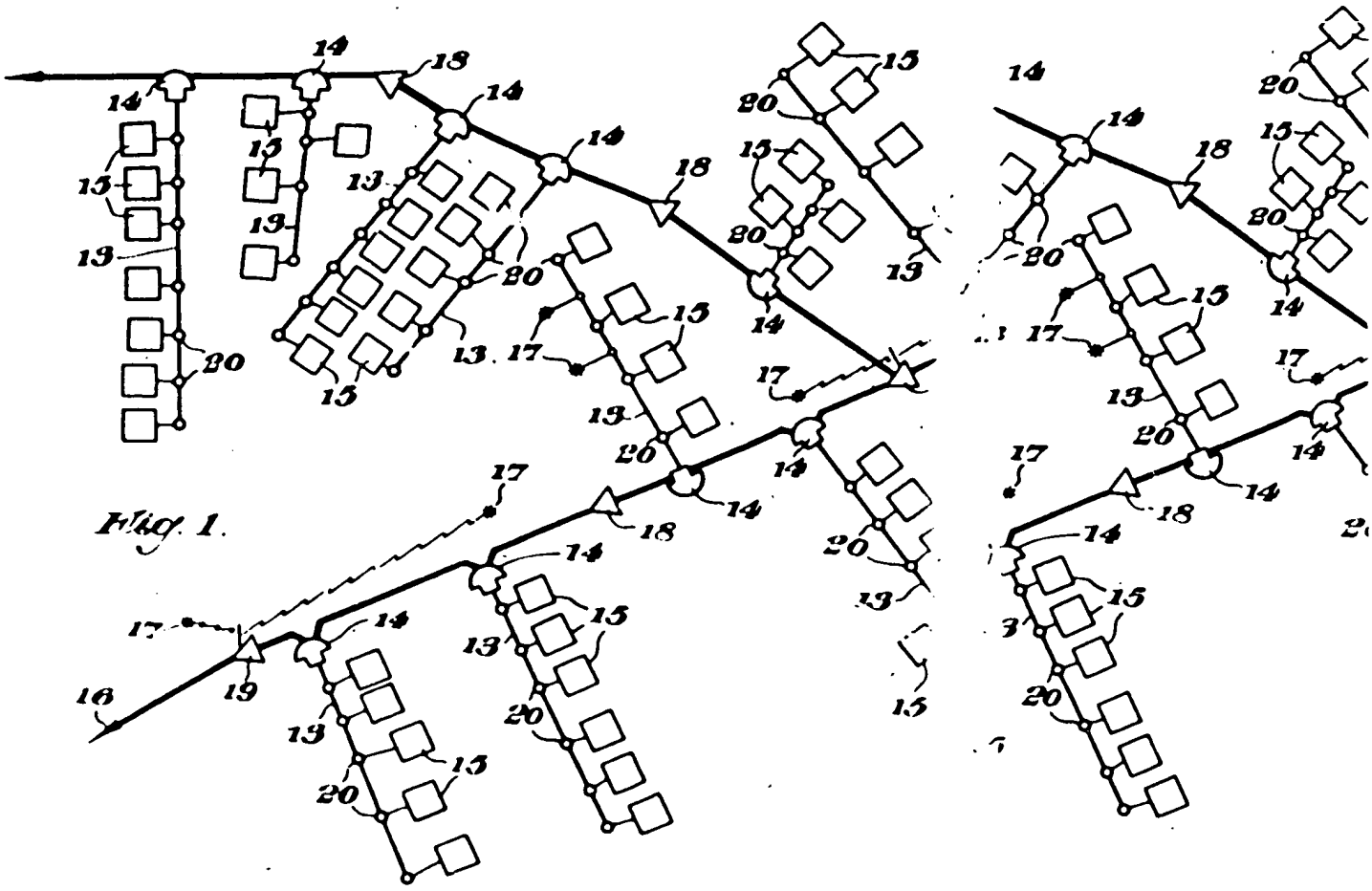
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Fig. 1.

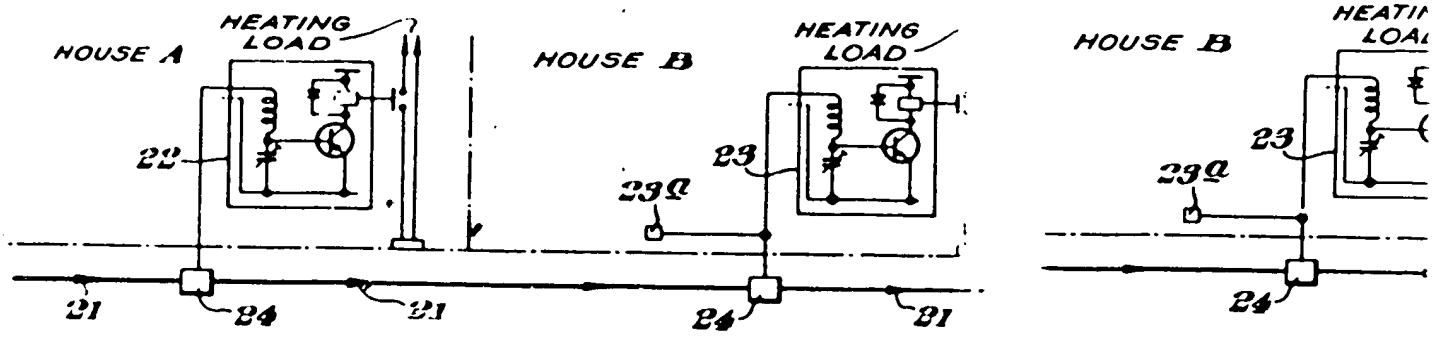
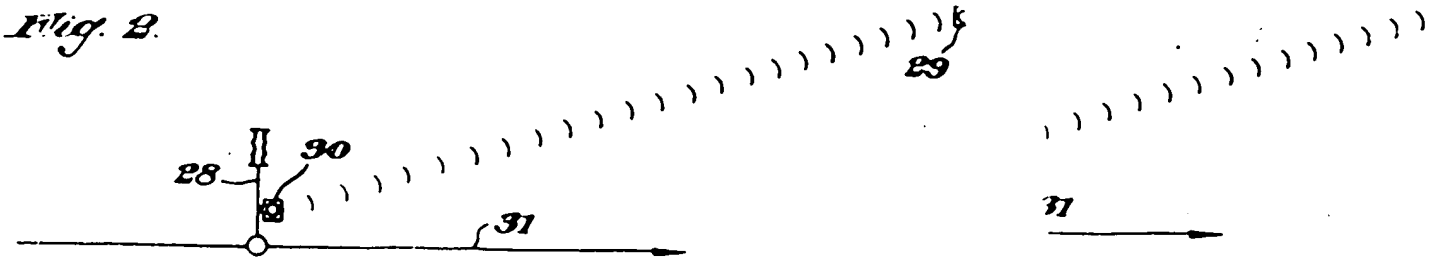

HOUSE A
HEATING LOAD
HOUSE B
HEATING LOAD
22
23
23a
21
24

Fig. 2.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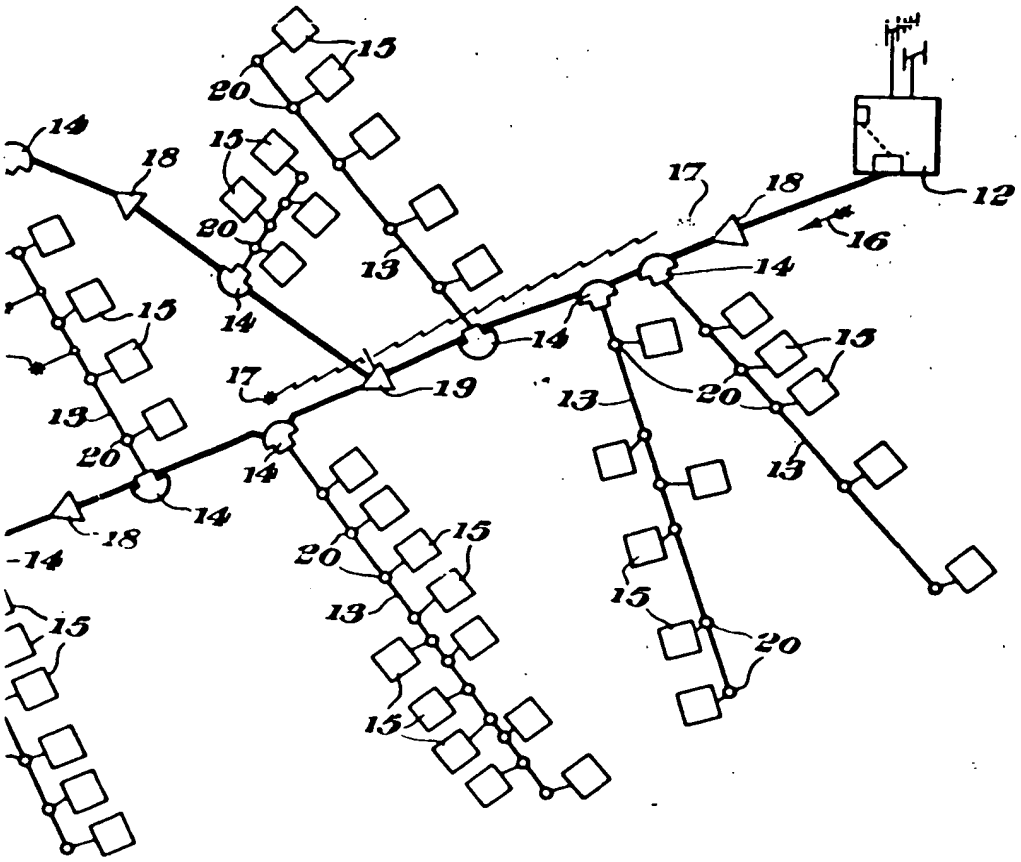


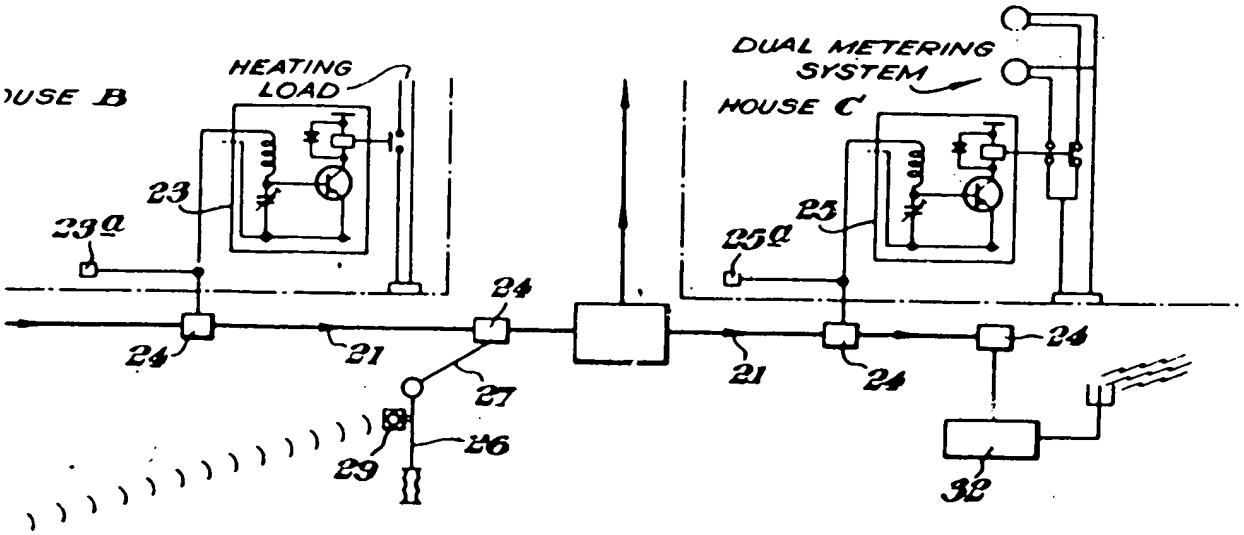

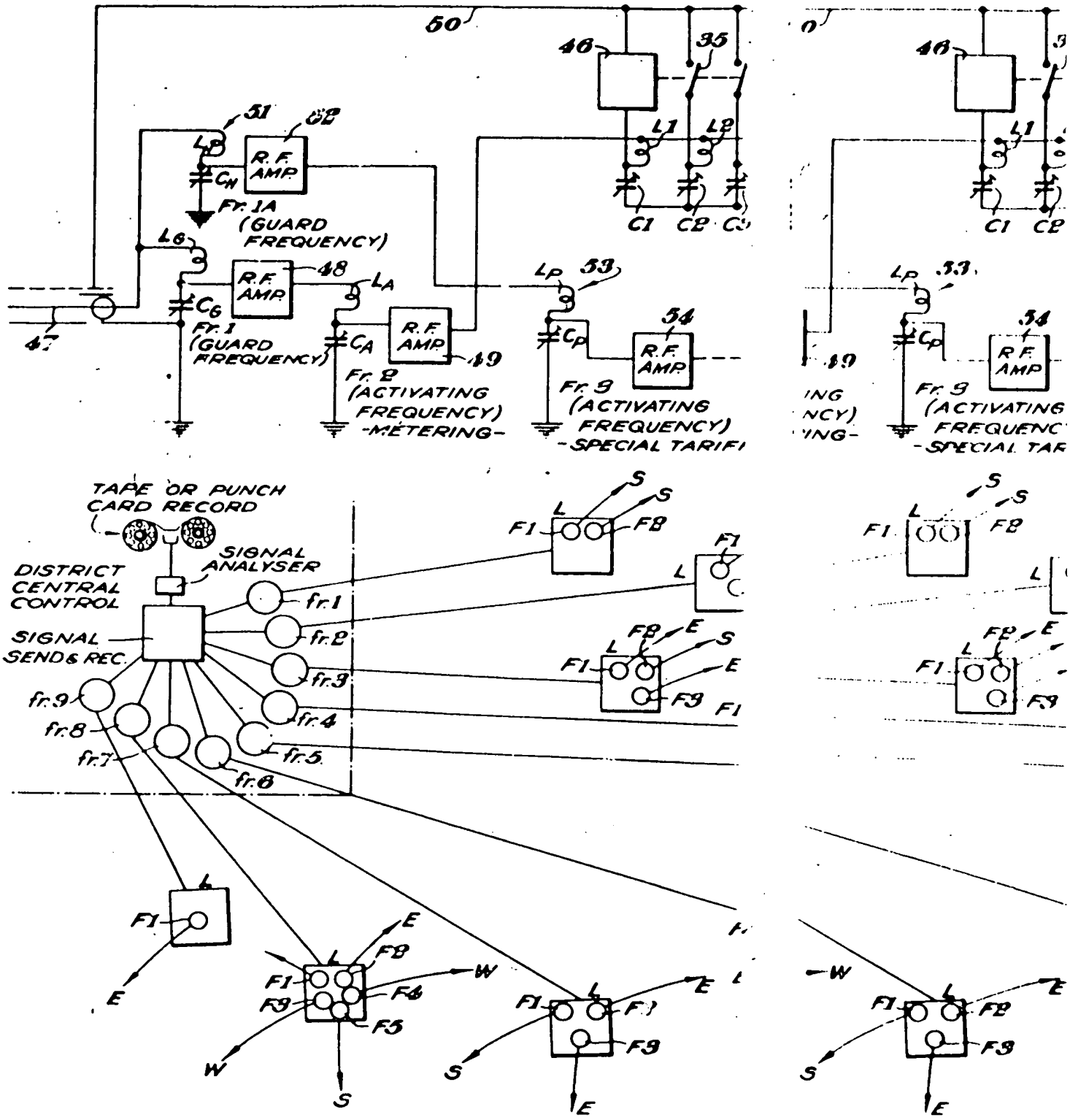
50
46
35
31
R.F. AMP
Fr. 1A (GUARD FREQUENCY)
48
Fr. 1 (GUARD FREQUENCY)
Fr. 2 (ACTIVATING FREQUENCY) -METERING-
49
33
34
Fr. 3 (ACTIVATING FREQUENCY) -SPECIAL TARIFI
TAPE OR PUNCH CARD RECORD
SIGNAL ANALYSER
DISTRICT CENTRAL CONTROL
SIGNAL SEND & REC.
fr.1
fr.2
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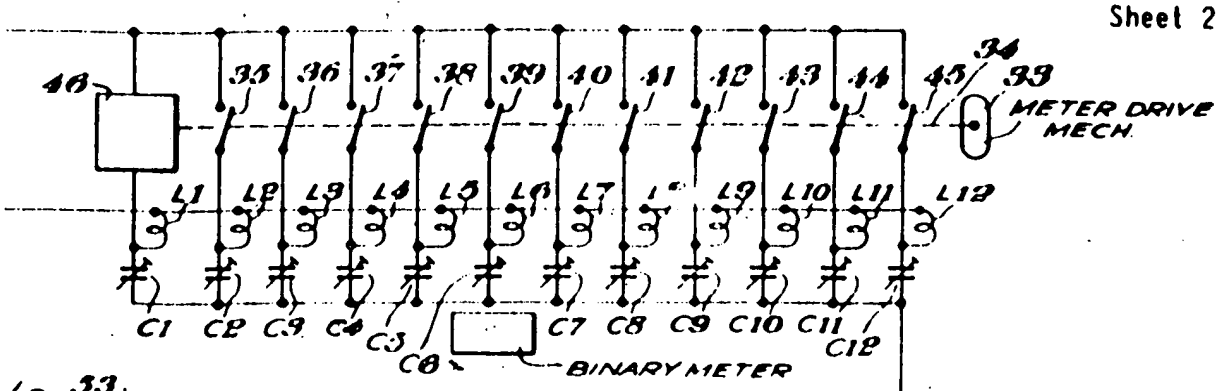
1140251 COMPLETE SPECIFICATION

2 SHEETS This drawing is a reproduction of the Original on a reduced scale.

Sheet 2



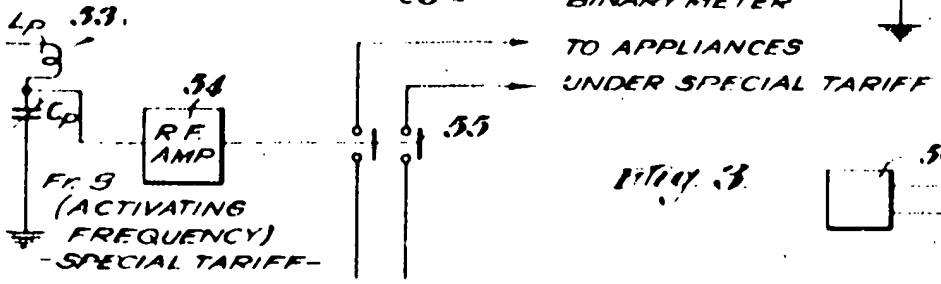




Fig 3

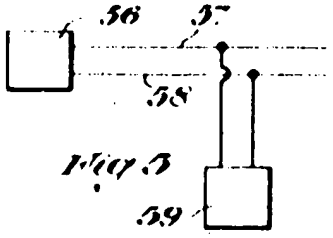



Fig 3

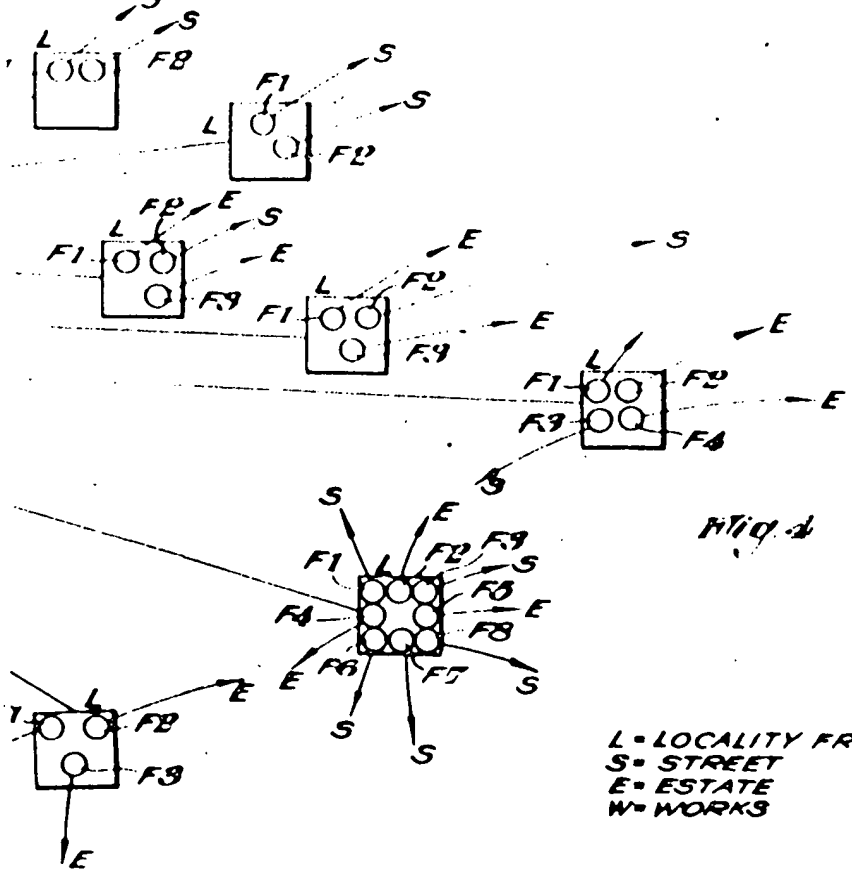



Fig 4

L = LOCALITY FREQUENCY
S = STREET
E = ESTATE
W = WORKS